Docket No. VIDI-003

APPLICATION

FOR UNITED STATES LETTERS PATENT

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, **Raymond Dueck**, a citizen of Canada, and **Maciej G. Wierzbowski**, a citizen of Canada, have invented a new and useful biomass gasification system of which the following is a specification:

Biomass Gasification System

CROSS REFERENCE TO RELATED APPLICATIONS

Not applicable to this application.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable to this application.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to biomass gasification and more specifically it relates to a biomass gasification system for efficiently extracting heat energy from biomass material.

Description of the Related Art

Biomass gasification processes have been in use for years for converting biomass into an energy source. Biomass gasification applications include water

boiling, steam generation, drying, motive power applications (e.g. using the producer gas as a fuel in internal combustion engines), and electricity generation.

Almost all kinds of biomass with moisture content of 5-30% can be gasified. Examples of suitable biomass include forest slash, urban wood waste, lumber waste, wood chips, sawdust, straw, firewood, agricultural residue, dung and the like. Under controlled conditions, characterized by low oxygen supply and high temperatures, most biomass materials can be converted into a gaseous fuel known as "producer gas", which consists of combustible mixture of nitrogen, carbon monoxide, and hydrogen. This thermo-chemical conversion of solid biomass into gaseous fuel is called biomass gasification.

Biomass gasification has many of the advantages associated with using gaseous and liquid fuels such as clean combustion, compact burning equipment, high thermal efficiency and a good degree of control. In locations where biomass is already available at reasonable low prices (e.g. agricultural areas) or in industries using fuel wood, biomass gasifier systems offer definite economic advantages. Biomass gasification technology is also environment-friendly, because of the fuel savings and reduction in CO_2 emissions.

The main problems with the application of biomass gasification systems have been economic, not technical. For example, conventional biomass gasification systems are typically suitable only for large-scale operations and not small-scale operations. Also, the product from gasification is mainly a heat source, and the low value of these products in today's market is insufficient to justify the capital and operating costs of conventional biomass gasification systems. Hence, there is a need for a biomass gasification system that is efficient and cost effective to operate with low cost biomass.

An example of a patented device this is related to the present invention is illustrated in U.S. Patent 2,171,535 to Berg et al. for an incineration system for disposal of refuse having high moisture content. However, the Berg et al. patent

reference does not have a piston feeder structure, a rotating grate within the primary combustion chamber, a silica collector system nor an oxygen mixer between the primary combustion chamber and the secondary combustion chamber.

While these devices may be suitable for the particular purpose to which they address, they are not as suitable for efficiently extracting heat energy from biomass material. Conventional biomass apparatus do not efficiently extract heat energy from the biomass material.

In these respects, the biomass gasification system according to the present invention substantially departs from the conventional concepts and designs of the prior art, and in so doing provides an apparatus primarily developed for the purpose of efficiently extracting heat energy from biomass material.

BRIEF SUMMARY OF THE INVENTION

In view of the foregoing disadvantages inherent in the known types of gasification apparatus now present in the prior art, the present invention provides a new biomass gasification system construction wherein the same can be utilized for efficiently extracting heat energy from biomass material.

The general purpose of the present invention, which will be described subsequently in greater detail, is to provide a new biomass gasification system that has many of the advantages of the gasification apparatus mentioned heretofore and many novel features that result in a new biomass gasification system which is not anticipated, rendered obvious, suggested, or even implied by any of the prior art gasification apparatus, either alone or in any combination thereof.

To attain this, the present invention generally comprises a primary combustion chamber, a rotating grate within the primary combustion chamber for supporting the biomass during gasification, a feeder unit in communication with the primary combustion chamber for delivering biomass, a secondary combustion chamber fluidly connected to the primary combustion chamber, an oxygen mixer positioned between the primary combustion chamber and the secondary combustion chamber, a heat exchanger and an exhaust stack.

There has thus been outlined, rather broadly, the more important features of the invention in order that the detailed description thereof may be better understood, and in order that the present contribution to the art may be better appreciated. There are additional features of the invention that will be described hereinafter and that will form the subject matter of the claims appended hereto.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of the description and should not be regarded as limiting.

A primary object of the present invention is to provide a biomass gasification system that will overcome the shortcomings of the prior art devices.

A second object is to provide a biomass gasification system for efficiently extracting heat energy from biomass material.

Another object is to provide a biomass gasification system that provides for usage of biomass gasification technologies within small-scale operations.

An additional object is to provide a biomass gasification system that is capable of utilizing various types of biomass materials readily available.

A further object is to provide a biomass gasification system that provides a cost effective alternative fuel source compared to conventional fossil fuels.

Another object is to provide a biomass gasification system that is environmentally friendly and utilizes renewable resources.

A further object is to provide a biomass gasification system that has efficiency ratings approaching 85%.

Another object is to provide a biomass gasification system that is automated and requires reduced maintenance.

A further object is to provide a biomass gasification system that may be utilized to produce heat, mechanical power or electricity.

Other objects and advantages of the present invention will become obvious to the reader and it is intended that these objects and advantages are within the scope of the present invention.

To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that changes may be made in the specific construction illustrated and described within the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

FIG. 1 is a side cutaway view of the present invention.

FIG. 2 is a side view of the fuel magazine and disintegration unit.

FIG. 3 is a side cutaway view of the primary combustion chamber.

FIG. 4 is a side cutaway view of the secondary combustion chamber.

FIG. 5 is a side cutaway view of the heat exchanger.

FIG. 6 is a side cutaway view of the exhaust stack.

FIGS. 7a-7c illustrate the operation of the feeder unit.

FIG. 8 is a side cutaway view of the primary combustion chamber with the fuel conveyor and disintegration unit.

FIG. 9 is a magnified side view of the fuel conveyor feeding biomass into the feeder unit.

FIG. 10 is a block diagram illustrating the overall control system for the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A. Overview

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, FIGS. 1 through 10 illustrate a biomass gasification sysem **10**, which comprises a primary combustion chamber **20**, a rotating grate **21** within the primary combustion chamber **20** for supporting the biomass during gasification, a feeder unit **70** in communication with the primary combustion chamber **20** for delivering biomass, a secondary combustion chamber **40** fluidly connected to the primary combustion chamber **20**, an oxygen mixer **30** positioned between the primary combustion chamber **20** and the secondary combustion chamber **40**, a heat exchanger **50** and an exhaust stack **60**.

B. Primary Combustion Chamber

The primary combustion chamber **20** is where the primary combustion occurs thereby converting the biomass to a producer gas as shown in Figures 1, 3 and 8 of the drawings. The primary combustion chamber **20** may be comprised of various structures commonly utilized within the gasification industry.

The interior portion of the primary combustion chamber **20** is preferably circular for receiving the rotating grate **21**, however various other interior cross sectional shapes may be utilized to construct the primary combustion chamber **20**. The primary combustion chamber **20** is preferably formed for gasifying various types of biomass such as but not limited to forest slash, urban wood waste, lumber waste, wood chips, sawdust, straw, firewood, agricultural residue, dung and the like.

As shown in Figures 1 and 3 of the drawings, an ash disposal unit **23** is preferably positioned beneath the rotating grate **21** for removing collected ash from the

primary combustion chamber **20**. The ash disposal unit **23** may be comprised of any well-known technology capable of removing ash from the primary combustion chamber **20**.

C. Rotating Grate

As shown in Figures 1, 3 and 8 of the drawings, the rotating grate **21** is rotatably positioned within a lower portion of the primary combustion chamber **20** for supporting the biomass during gasification. The rotating grate **21** preferably has a flat structure, however various other structures may be utilized to construct the rotating grate **21**. The rotating grate **21** may be comprised of various rigid materials capable of withstanding high temperatures such as but not limited to metal.

The rotating grate **21** preferably includes a plurality of openings within it for allowing air to pass upwardly through the biomass positioned upon the rotating grate **21** thereby feeding the primary combustion. The openings within the rotating grate **21** may have various sizes, shapes and patterns that allow air to pass through into the biomass as can be appreciated.

The rotating grate **21** preferably has a shape and size similar to an interior of the primary combustion chamber **20** thereby preventing biomass from falling between the outer perimeter of the rotating grate **21** and the inner wall of the primary combustion chamber **20**. The rotating grate **21** is rotatably supported within the lower portion of the primary combustion chamber **20** utilizing a support structure within the primary combustion chamber **20**. The rotating grate **21** preferably is substantially transverse with respect to a longitudinal axis of the primary combustion chamber **20** as shown in Figures 1, 3 and 8 of the drawings.

In addition, a drive motor **27** is mechanically connected to the rotating grate **21** for rotating the rotating grate **21**. The drive motor **27** may be comprised of any well-

known motor structure such as electric, hydraulic and the like. The drive motor **27** may be mechanically connected to the rotating grate **21** via various conventional connection means such as gears, chains, drive shaft **76** and the like.

As shown in Figures 1 and 3 of the drawings, an air distribution system **22** is positioned within the primary combustion chamber **20** beneath the rotating grate **21** for forcing air beneath the rotating grate **21** through the openings. The air distribution system **22** draws fresh air from outside of the primary combustion chamber **20** into the primary combustion area to assist in increasing the temperature of the primary combustion. The air distribution system **22** may be comprised of various devices capable of forcing air into the primary combustion chamber **20**.

D. Feeder Unit

The feeder unit **70** is in communication with the primary combustion chamber **20** for delivering biomass onto the rotating grate **21** as shown in Figure 1 and 8 of the drawings. The feeder unit **70** preferably includes a disintegration unit **26** for disintegrating the biomass before entering the primary combustion chamber **20**, thereby increasing the rate of breakdown for the biomass within the primary combustion chamber **20**.

The feeder unit **70** also preferably includes a biomass magazine **25** capable of storing a volume of the biomass for inputting biomass into the disintegration unit **26**. For example, if straw bales are used in the present invention as the biomass, then the biomass magazine **25** would be capable of delivering bales of the straw into the disintegration upon demand. A biomass storage bin **24** stores a volume of the biomass prior to entering the biomass magazine **25**. The biomass storage bin **24** may be capable of storing various volumes of biomass.

As shown in Figures 7a-7c of the drawings, the feeder unit **70** preferably includes a plunger member **78** that pushes the biomass into an opening surrounded by an input member **29** within the primary combustion chamber **20** onto the rotating grate **21**. The plunger member **78** is slidably positioned within the input member **29** as illustrated in Figures 7a-7c of the drawings.

The opening within the primary combustion unit is preferably aligned with or slightly above the upper surface of the rotating grate **21** as shown in Figures 7a-7c and 9 of the drawings. The input member **29** is preferably comprised of a tubular structure that allows forcing of the biomass into the primary combustion chamber **20** as shown in Figures 7a-7c of the drawings.

The plunger member **78** moves along a path radial to the rotating grate **21** and has a cyclical action. The cyclical action of the plunger member **78** allows for new biomass to be inserted into the primary combustion chamber **20** as the rotating grate **21** rotates. As the new biomass is forced onto the rotating grate **21**, the remaining biomass is forced inwardly and the ashes pass through the rotating grate **21** to allow for the new biomass.

The feeder unit **70** preferably includes a conveyor **28** positioned between the disintegration unit **26** and the primary combustion chamber **20** for transferring the particulate biomass into the primary combustion chamber **20**. The conveyor **28** positions the new biomass into an upper opening within the input member **29** where after the plunger member **78** drives the biomass into the primary combustion chamber **20**.

Various well-known mechanical devices may reciprocally drive the plunger member **78**. A suitable mechanical device for driving the plunger member **78** is comprised of a flywheel **74** connected to a motor unit **72** and a drive shaft **76** attached

to an outer portion of the flywheel **74** and to the plunger member **78**. Various other devices may be utilized to drive the plunger member **78**. In addition, various other structures may be utilized to input the biomass into the primary combustion chamber **20** instead of the plunger member **78**.

E. Oxygen Mixer

The oxygen mixer **30** is positioned between the primary combustion chamber **20** and the secondary combustion chamber **40** as best shown in Figure 1 of the drawings. The oxygen mixer **30** is in communication with the control unit **12** and allows a desired volume of oxygen or air into the transfer tube **32** positioned between the primary combustion chamber **20** and the secondary combustion chamber **40**. The transfer tube **32** preferably has a cross section substantially smaller than the primary combustion chamber **20** to create a high velocity jet stream of producer gas entering the secondary combustion chamber **40**.

The oxygen mixer **30** preferably inputs the oxygen into the producer gas emitted from the biomass in the primary combustion chamber **20** to increase the temperature of the secondary combustion to 2,000+ degrees Fahrenheit. As the producer gas increases in volume and velocity, the oxygen mixer **30** ensures that sufficient oxygen exists prior to entering the secondary combustion within the upper portion of the secondary combustion chamber **40**.

F Secondary Combustion Chamber

The secondary combustion chamber **40** is fluidly connected to the primary combustion chamber **20** via the transfer tube **32** at the upper portions thereof as best shown in Figure 1 of the drawings. The second combustion chamber preferably has a substantially smaller cross section than the primary combustion chamber **20** for increasing the velocity of the gases.

As the producer gas and oxygen enter the upper portion of the second combustion chamber, a secondary combustion is formed that can exceed 2,000+ degrees Fahrenheit. At this temperature, contaminants and other material are burned completely thereby providing a clean and reduced pollution exhaust.

In addition, silica in the form of liquid typically is formed on the inner walls of the secondary combustion chamber **40** that is collected within the silica collector **42** at the bottom of the secondary combustion chamber **40** as shown in Figures 1 and 4 of the drawings. The silica may be collected into various types of containers such as but not limited to carts.

Alternatively, a liquid may be positioned within the silica container that pulverizes the silica chunks that fall into at an extreme temperature, where after the silica debris may be cleaned from the liquid. The silica collector **42** prevents the buildup of silica within the secondary combustion chamber **40** when straw and similar biomass are utilized with relatively high silica content.

G. Heat Exchanger

The heat exchanger **50** is fluidly connected to a lower portion of the secondary combustion chamber **40** as best shown in Figures 1 and 5 of the drawings. The heat exchanger **50** preferably includes a particle collector **52** for collecting particle waste remaining within the exhaust of the secondary combustion that falls downwardly from within the heat exchanger **50**.

It can be appreciated that a conventional heat exchanger **50** may be utilized that allows cool water to enter into pipes within the heat exchanger **50** that conduct the heat from the highly heated exhaust gas. The hot water then exits the heat exchanger **50** for use in producing electricity, heat for thermal applications and the like.

The preferred structure for a heat exchanger **50** is shown in Figure 5 wherein a fluid tank retaining a volume of water or other liquid has a plurality of exhaust pipes passing through thereof. The heated exhaust gas passes through the exhaust pipes within the fluid tank thereby heating the liquid within the fluid tank. An auger structure is utilized to remove collected particle waste from within the interior of the exhaust pipes.

H. Control Unit

As shown in Figure 10 of the drawings, the control unit **12** is in communication with the oxygen mixer **30**, the disintegration unit **26**, the feeder unit **70**, the air distribution system **22**, the exhaust blower **62**, the drive motor **27** and the fuel conveyor **28**. The control unit **12** may be in communication with these devices via direct electrical connection, radio signal or other communication means.

The control unit **12** also is in communication with various sensors **14** within the primary combustion chamber **20**, the secondary combustion chamber **40**, the heat exchanger **50** and the exhaust stack **60** to monitor the performance of the system and adjust the components accordingly. The control unit **12** may be comprised of a computer or other electronic device capable of storing various types of data including input data, program data and the like.

I. Operation

In use, the biomass is loaded within the biomass storage bin **24**. The biomass is then automatically loaded into the biomass magazine **25** which then feeds the biomass into the disintegration unit **26**. The broken down biomass is then transferred along the conveyor **28** into the primary combustion chamber **20**. The biomass is fed into the input member **29** where after the plunger member **78** forces the biomass into the primary combustion chamber **20** onto the rotating grate **21** as shown in Figures 7a-7c of the drawings. The new biomass within the primary combustion chamber **20** is

thereafter broken down by the primary combustion within the primary combustion chamber **20** into producer gas. The producer gas rises to the upper portion of the interior of the primary combustion chamber **20** and then enters the transfer tube **32**. As the producer gas passes through the transfer tube **32** a high velocity, the oxygen mixer **30** inputs oxygen within the producer gas which is then dispersed into the upper portion of the secondary combustion chamber **40** where the secondary combustion occurs at a high temperature (exceeding 2,000 degree Fahrenheit). Silica and other debris is collected within the silica collector **42** at the bottom of the secondary combustion chamber **40**. The super heated exhaust gas then enters the heat exchanger **50** to heat a liquid or perform another function for transferring the heat energy. The cooled exhaust gas thereafter passes downwardly to a lower portion of an exhaust stack **60** where an exhaust blower **62** assists in transferring the cooled exhaust gas outwardly through the exhaust stack **60**.

As to a further discussion of the manner of usage and operation of the present invention, the same should be apparent from the above description. Accordingly, no further discussion relating to the manner of usage and operation will be provided.

With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed to be within the expertise of those skilled in the art, and all equivalent structural variations and relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction

and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.